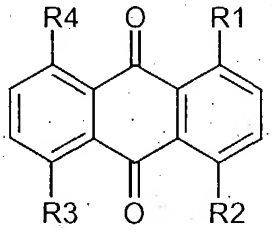
What is claimed is:

1. A pharmaceutical compound according to Formula I,



FORMULA I

wherein R1, R2, R3 and R4 are selected from the group consisting of a straight or branched chain alkyl group having 1 to 6 carbons substitutes with one or more Ra groups, a benzyl group, a phenyl group which is substituted with one or two Rb groups, and a benzyl group which is substituted with one or two Rb groups;

wherein R1, R2, R3 and R4 are selected from the group consisting of halogen, $-NO_2$, $-OCH_3$, $-OCH_2CH_3$, $-CH(CH_3)_2$, $-(CH_2)_nOH$, $-(CH_2)_nNH$, $-CH_2CH_2N(CH_3)_2$, $-CH_2CH_2NH(CH_2)_2OH$, cyclopentane, 2,3-$(CH_3)_2$-cyclohexane, -S-Rc, -O-CO-Rd, -N-Re, -CO-Rf, -CONH-Rg; and

wherein Ra, Rb, Rc, Rd, Re, Rf, Rg are selected from the group consisting of a straight or branched chain alkyl group having 1 to 6 carbons, $-NO_2$, $-OCH_3$, $-OCH_2CH_3$, $-CH(CH_3)_2$, $-(CH_2)_nOH$, $-(CH_2)_nNH$, $-CH_2CH_2N(CH_3)_2$, $-CH_2CH_2NH(CH_2)_2OH$, cyclopentane, 2,3-$(CH_3)_2$-cyclohexane, -S-, -OCO-, -N-, -CO-, -CONH-.

2. The compound according to claim 1, wherein R1, R2, R3 and R4 represent a substituted phenyl, benzyl, ethylphenyl, cyclopentane, and 2,3-$(CH_3)_2$-cyclohexane groups selected from the group consisting of 2-$CH_3C_6H_4$, 3-$CH_3C_6H_4$, 4-$CH_3C_6H_4$, 2-OHC_6H_4, 3-OHC_6H_4, 4-OHC_6H_4, 2-ClC_6H_4, 3-ClC_6H_4, 4-ClC_6H_4, 2-$NO_2C_6H_4$, 3-$NO_2C_6H_4$, 4-$NO_2C_6H_4$, 2-$NH_2C_6H_4$, 3-$NH_2C_6H_4$, 4-$NH_2C_6H_4$, and 2,4-$Cl_2C_6H_3$.

3. The compound according to claim 1, wherein R1, R2, R3 and R4 represent a substituted alkyl group selected from the group consisting of CH_2Br, CH_2Cl, CH_2OH, $C(CH_3)_3$, $(CH_2)_2OH$, $(CH_2)_3OH$, $(CH_2)_4OH$, CH_2NH_2, $(CH_2)_2NH_2$, $(CH_2)_3NH_2$, $(CH_2)_4NH_2$, $(CH_2)_5NH_2$, $CH_2N(CH_3)_2$, $(CH_2)_2N(CH_3)_2$, $(CH_2)_2NH(CH_2)_2OH$, $(CH_2)_3NH(CH_2)_2OH$, $(CH_2)_2NHCH_2OH$, $(CH_2)_3NHCH_2OH$, $CH_2CH(CH_3)_2$, $CHCl_2$, $CH(CH_3)Cl$, $(CH_2)_2Cl$, $(CH_2)_3Cl$, $(CH_2)_3Br$, $(CH_2)_4Br$, and $(CH_2)_4Cl$.

4. An anti-cancer drug, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

5. A telomerase effect drug, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

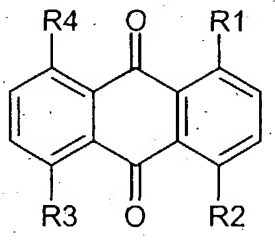
6. An anti-inflammatory drug, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

7. An anti-oxidant drug, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

8. An anti-psoriatic drug, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

9. A stem cell and tissue engineering application, comprising, as an active ingredient, the pharmaceutical compound of claim 1.

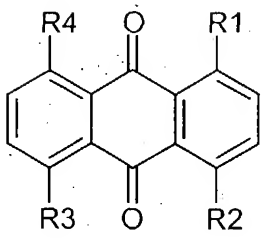
10. A compound having the chemical structure of Formula I,



FORMULA I

wherein R1, R2, R3 and R4 represent cyclopentane, cyclohexane, $-C_6H_5$, $-CH_2C_6H_5$, or $-CH_2CH_2C_6H_5$, group having one, two or three substituents which is selected from the group of halogen, OH, CH_3, OCH_3, NH_2, and NO_2.

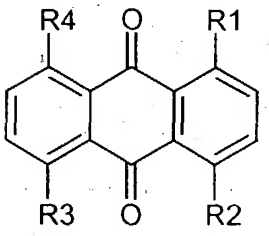
11. A compound having the chemical structure of Formula I,



FORMULA I

wherein R1, R2, R3 and R4 represent -S-, -O-CO-, -N-, -CO-, and -CONH-, consisting of a straight or branched chain alkyl group having 1 to 6 carbons, and CH_2Br, CH_2Cl, CH_2OH, $C(CH_3)_3$, $(CH_2)_2OH$, $(CH_2)_3OH$, $(CH_2)_4OH$, CH_2NH_2, $(CH_2)_2NH_2$, $(CH_2)_3NH_2$, $(CH_2)_4NH_2$, $(CH_2)_5NH_2$, $CH_2N(CH_3)_2$, $(CH_2)_2N(CH_3)_2$, $(CH_2)_2NH(CH_2)_2OH$, $(CH_2)_3NH(CH_2)_2OH$, $(CH_2)_2NHCH_2OH$, $(CH_2)_3NHCH_2OH$, $CH_2CH(CH_3)_2$, $CHCl_2$, $CH(CH_3)Cl$, $(CH_2)_2Cl$, $(CH_2)_3Cl$, $(CH_2)_3Br$, $(CH_2)_4Br$, and $(CH_2)_4Cl$.

12. A method for synthesis of bis-substituted anthraquinone compounds and salts thereof, comprising reacting 1,5-dichloroanthraquinone, anthrarufin, 1,8-dichloroanthraquinone, 1,5-diaminoanthraquinone or 1,8-diaminoanthraquinone with an appropriate acyl chlorides, thiols, or amines under appropriate conditions to give the bis-substituted anthraquinones according to Formula I



FORMULA I

wherein R1, R2, R3 and R4 are selected from the group consisting of a straight chain alkyl group having 1 to 6 carbons which is optionally substituted with one or more R groups, a branched chain alkyl group having 1 to 6 carbons which is optically substituted with one or more R groups, cyclopentane, 2,3-$(CH_3)_2$-cyclohexane, $-C_6H_5$, $-CH_2C_6H_5$, or $-CH_2CH_2C_6H_5$, a phenyl which is substituted with one or more R groups, and a benzyl group which is optionally substituted with one or more R groups, and $-CH_2CH_2C_6H_5$ group which is optionally substituted with one or more R groups;

wherein R is selected from the group consisting of halogen, OH, CH_3, OCH_3, NH_2, and NO_2.

13. A method for anti-cancer treatment, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

14. A method for treating abnormal proliferation, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

15. A method for enhancing an anti-oxidation affect, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

16. A method for enhancing human telomerase activity, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

17. A method for stem cell research, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

18. A method for enhancing tissue engineering application, comprising administering a therapeutically effective amount of a pharmaceutical compounds according to claim 11 or a pharmaceutically acceptable salt of said compound and optionally a pharmaceutical carrier to a patient in need of such treatment.

19. An anti-cancer drug, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

20. An anti-inflammatory drug, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

21. An anti-oxidant drug, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

22. An anti-psoriatic drug, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

23. Drug for telomerase activation or inhibition, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

24. Drug for stem cell application, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

25. Drug for tissue engineering, comprising, as an active ingredient, the pharmaceutical compound of claim 11.

Table 1. Cytotoxicity Against the Growth of Suspended Murine and Human Tumor Cell Lines and Inhibitory Effect of Anthraquinone Derivatives (IIa-k)on Iron-induced Lipid Peroxidation in Rat Brain Homogenates.

Compound	R	IC_{50} (μM)[a]		LP (%) (10 mM)[b]
		Hep G2 [c]	C6 cells [d]	
IIa	CH_2CH_3	12.2 ± 1.1	0.02 ± 0.01	83 ± 2.2
IIb	CH_2CH_2OH	36.4 ± 1.5	21.5 ± 0.8	16 ± 2.2
IIc	$CH_2CH_2CH_3$	75.1 ± 2.5	29.9 ± 2.1	15 ± 1.5
IId	$CH_2CH(OH)CH_2OH$	34.3 ± 1.8	38.5 ± 1.5	83 ± 1.1
IIe	$(CH_2)_6OH$	49.3 ± 2.1	31.7 ± 1.6	54 ± 1.9
IIf	$2\text{-}NH_2C_6H_4$	34.0 ± 1.7	15.1 ± 1.7	5 ± 0.5
IIg	$3\text{-}NH_2C_6H_4$	21.5 ± 1.2	26.3 ± 2.8	6 ± 0.9
IIh	$4\text{-}NH_2C_6H_4$	17.4 ± 1.5	0.05 ± 0.01	20 ± 1.4
IIi	$CH_2C_6H_5$	41.5 ± 2.5	38.2 ± 4.4	>100
IIj	$CH_2C_6H_4(OCH_3)(p)$	28.6 ± 1.2	25.1 ± 2.8	67 ± 2.9
IIk	$CH_2CH_2C_6H_5$	36.9 ± 1.5	32.9 ± 3.3	69 ± 1.5
	Mitoxantrone	2.0 ± 0.5	0.07 ± 0.01	54 ± 1.5
	Ascorbic acid			>100
	(+)–α-Tocopherol			>100
	Anthrarufin			-36 ± 1.9

[a]IC_{50}, drug concentration inhibiting 50% of cellular growth following 48 h of drug exposure. Values are in μM and represent an average of three experiments. The variance for the IC_{50} values was less than ± 20%. Inhibition of cell growth was significantly different with respect to that of the control; $n = 3$ or more, $P < 0.01$. [b]Relative percentage of inhibition. Inhibition was compared with that of the control (ascorbic acid, α-tocopherol and mitoxantrone-HCl), $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent inhibition at the indicated concentration (μM), and standard errors. [c]Hep G2, human hepatoma G2 cells. [d]C6 cells, rat glioma C6 cells.

Table 2. Inhibitory Effects of IIi on Iron-induced Lipid Peroxidation in Rat Brain Homogenates.

Compound	Inhibition (%)[a]			
	10 mM	1 mM	0.1 mM	0.01 mM
IIi	>100	95	60 ± 2.0	24 ± 0.8
Ascorbic acid	100	75 ± 1.5	32 ± 1.2	10 ± 0.6
(+)-α-Tocopherol	100	55 ± 1.7	0	0
Mitoxantrone-HCl	100	54 ± 2.1	22 ± 3.5	5 ± 0.3

[a]Relative percentage of inhibition. Inhibition was compared to that of the control (ascorbic acid, (+)-α-tocopherol and mitoxantrone-HCl); $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent inhibition at the indicated concentration (mM) with standard errors.

Table 3. Cytotoxicity against the growth of suspended murine and human tumors and inhibitory effect of anthraquinone derivatives (IIIa-n) on iron-induced lipid peroxidation in rat brain homogenates.

Compd	R	IC_{50} (μM)[a]		Inhibition of LP (10 mM)[b]
		Hep G2 [c]	C6 cells [d]	
IIIa	CH_2CH_3	4.1 ± 0.5	21.1 ± 1.6	-100
IIIb	$CH_2CH_2CH_3$	0.02 ± 0.01	38.5 ± 2.8	54 ± 2.2
IIIc	$CH_2CH_2CH_2CH_2CH_3$	36.2 ± 2.5	39.1 ± 4.1	-55 ± 1.5
IIId	$C(CH_3)_3$	13.7 ± 1.8	12.0 ± 1.5	-23 ± 1.1
IIIe	C_6H_5	47.7 ± 5.5	38.7 ± 3.6	-50 ± 1.9
IIIf	2-ClC_6H_4	0.04 ± 0.01	40.7 ± 4.7	5 ± 0.5
IIIg	3-ClC_6H_4	15.1 ± 1.9	25.1 ± 2.8	1 ± 0.1
IIIh	4-ClC_6H_4	48.1 ± 4.5	38.6 ± 3.5	2 ± 0.2
IIIi	2,4-$Cl_2C_6H_3$	>50	38.4 ± 4.4	-1 ± 0.1
IIIj	2-$CH_3C_6H_4$	21.6 ± 2.2	25.1 ± 2.8	23 ± 1.1
IIIk	3-$CH_3C_6H_4$	18.1 ± 1.5	30.1 ± 3.3	-32 ± 1.5
IIIl	4-$CH_3C_6H_4$	9.3 ± 0.9	37.6 ± 4.1	33 ± 1.2
IIIm	$CH_2C_6H_5$	9.0 ± 1.5	39.1 ± 6.2	-1 ± 0.2
IIIn	$CH_2CH_2C_6H_5$	0.4 ± 0.1	40.1 ± 5.5	>100
	mitoxantrone	2.0 ± 0.5	0.07 ± 0.01	>100
	ascorbic acid			>100
	(+)–α-tocopherol			>100
	anthrarufin			-36 ± 1.1

[a] IC_{50}, drug concentration inhibiting 50% of cellular growth following 48 h of drug exposure. Values are in μM and represent an average of three experiments. The variance for the IC_{50} was less than ±20%. Inhibition of cell growth was significantly different with respect to that of the control; N = 3 or more, $P < 0.01$. [b] Relative percentage of inhibition. Inhibition was compared to that of the control [ascorbic acid, α-tocopherol and mitoxantrone-HCl], $P < 0.01$, Mean ± S.E., n = 4. Values are mean percent inhibition at the indicated concentration (mM), and standard errors.

[c] Hep G2: human hepatoma G2 cells. [d] C6 cells: rat glioma C6 cells.

Table 4. Inhibitory effects of IIIn on iron-induced lipid peroxidation in rat brain homogenates.

	Inhibition (%)[a]			
Compound	10mM	1 mM	0.1 mM	0.01 mM
IIIn	>100	>100	95 ± 2.0	50 ± 0.8
ascorbic acid	100	75 ± 1.5	32 ± 1.2	10 ± 0.6
(+)–α-tocopherol	100	55 ± 1.7	0	0
mitoxantrone-HCl	100	54 ± 2.1	22 ± 3.5	5 ± 0.3

[a]Relative percentage of inhibition. Inhibition was compared to that of the control ascorbic acid, (+)–α-tocopherol and mitoxantrone-HCl], $P < 0.01$, Mean ± S.E., $n = 4$. Values are mean percent inhibition at the indicated concentration (mM), and standard errors.

Table 5. In vitro Cytotoxicity of Diaminoanthraquinones (IVa-s) Against the Growth of Suspended Murine and Human Tumor Cell Lines

Compound	R	IC_{50} (μM)[a]		
		Hep G2[b]	C6 cells[c]	2.2.15[d]
IVa	CH_2CH_3	>20	>20	>20
IVb	CH_2CH_2OH	>20	>20	19.26±2.2
IVc	$CH(CH_3)_2$	7.64±2.38	>20	18.98±2.4
IVd	$CH_2CH_2N(CH_3)_2$	0.09±0.01	0.12±0.01	0.13±0.01
IVe	$CH_2CH_2NH(CH_2)_2OH$	1.20±0.02	1.17±0.03	8.35±0.11
IVf	$CH_2CH_2CH_3$	1.74±0.14	16.03±0.68	1.94±0.02
IVg	$CH_2CH(CH_3)_2$	14.27±1.54	12.67±0.37	>20
IVh	$CH_2CH_2CH_2OH$	>20	>20	>20
IVi	$CH_2CH_2CH_2NH_2$	11.67±0.09	12.18±0.04	7.48±0.09
IVj	$CH_2CH_2CH_2CH_3$	>20	>20	>20
IVk	$CH_2CH_2CH_2CH_2OH$	>20	>20	10.30±0.24
IVl	$CH_2CH_2CH_2CH_2NH_2$	11.61±0.02	12.56±0.16	10.07±0.58
IVm	$CH_2CH_2CH_2CH_2CH_2NH_2$	17.37±0.74	8.36±0.13	>20
IVn	$CH_2CH_2CH_2CH_2CH_2CH_3$	>20	>20	>20
IVo	cyclopentane	>20	>20	>20
IVp	2,3-$(CH_3)_2$-cyclohexane	>20	>20	>20
IVq	4-OHC_6H_4	4.20±0.76	14.21±0.08	>20
IVr	$CH_2C_6H_5$	>20	>20	>20
IVs	$CH_2CH_2C_6H_5$	>20	>20	>20
	Mitoxantrone	2.00±0.5	0.07±0.01	0.40±0.02
	Adriamycin	0.90±0.01	1.00±0.16	1.60±0.04
	Cisplatin	1.48±0.62	>1	2.0±0.54

[a]IC_{50}, drug concentration inhibiting 50% of cellular growth following 48 h of drug exposure. Values are in μM and represent an average of three experiments. The variance for the IC_{50} values was less than ±20%. Inhibition of cell growth was significantly different with respect to that of the control; $n = 3$ or more, $P < 0.01$. Inhibition was compared with that of control (mitoxantrone-HCl, adriamycin, cisplatin), (μM), and standard errors. [b]Hep G2, human hepatoma G2 cells. [c]C6 cells, rat glioma C6 cells. [d]2.2.15 cells, hepatitis B virus transfected hepatoma cell lines, HepG 2.2.15 cells.

Table 6. Effects of Symmetrical 1,5-Diaminoanthraquinones (IVa-p) on Activating hTERT Expression

No.	R	Conc. (μM)[a]	P_{hTERT}-SEAP (hTERT-BJ1)[b] Relative MTT viability (%)	Relative SEAP activity (%)	SEAP/vibility
IVa	CH_2CH_3	3.3	100±4.8	94±17.4	0.94
		33	97±1.0	96±8.5	1.00
		339	99±3.2	66±11.8	0.67
IVb	CH_2CH_2OH	3.0	116±5.6	45±20.6	0.39
		30	90±26.9	16±13.1	0.18
		308	69±18.7	11±11.6	0.16
IVc	$CH(CH_3)_2$	3.1	101±4.5	32±18.3	0.32
		31	93±6.5	23±20.5	0.25
		310	98±12.9	(-2)±15.3	-0.02
IVd	$CH_2CH_2N(CH_3)_2$	2.6	92±4.8	11±22.4	0.12
		26	76±5.9	(-15)±18.2	-0.19
		262	7±18.2	(-26)±16.9	-3.77
IVe	$CH_2CH_2NH(CH_2)_2OH$	2.4	84±19.8	60±11.6	0.72
		24	60±11.2	40±17.3	0.67
		242	44±12.9	52±19.1	1.18
IVf	$CH_2CH_2CH_3$	3.1	97±5.6	18±16.7	0.18
		31	93±8.9	19±24.6	0.20
		310	42±8.1	(-7)±27.1	-0.16
IVg	$CH_2CH(CH_3)_2$	2.8	110±7.6	22±18.3	0.20
		28	103±3.0	22±21.4	0.21
		285	72±3.3	29±3.9	0.41
IVh	$CH_2CH_2CH_2OH$	2.8	72±7.4	41±12.5	0.57
		28	39±10.5	0±22.1	0.01
		282	26±15.9	(-3)±10.0	-0.10
IVi	$CH_2CH_2CH_2NH_2$	2.8	85±6.9	103±19.8	1.22
		28	3±6.9	47±20.5	15.35
		283	(-2)±7.7	60±15.1	-28.94

IVj	$CH_2CH_2CH_2CH_3$	2.8	109±9.1	98±27.4	0.89
		28	99±5.9	103±27.0	1.04
		285	75±5.9	123±22.9	1.64
IVk	$CH_2CH_2CH_2CH_2NH_2$	2.6	101±10.5	114±20.5	1.13
		26	101±8.8	113±21.6	1.12
		265	91±11.8	127±19.9	1.39
IVl	$CH_2CH_2CH_2CH_2CH_2CH_3$	2.4	106±3.9	90±19.5	0.85
		24	97±4.6	97±17.9	1.00
		245	68±8.5	122±30.2	1.79
IVm	cyclopentane	2.6	104±3.6	18±20.1	0.18
		26	102±4.0	14±29.6	0.14
		267	87±4.6	34±16.5	0.39
IVn	2,3-$(CH_3)_2$-cyclohexane	2.1	118±10.6	94±20.2	0.80
		21	99±8.2	92±17.4	0.93
		218	84±6.9	90±22.7	1.07
IVo	$CH_2C_6H_5$	2.3	110±4.1	110±14.8	1.00
		23	102±5.3	92±13.8	0.91
		238	74±4.9	86±13.8	1.15
IVp	$CH_2CH_2C_6H_5$	2.2	97±4.0	115±12.9	1.18
		22	92±1.0	103±12.3	1.12
		223	81±4.7	133±23.8	1.65
	Mitoxnatrone	1.9	75±2.9	30±5.8	0.40
		19	56±3.1	13±9.2	0.24
		193	10±2.0	4±14.2	0.38

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Activity of P_{hTERT}-SEAP (hTERT-BJ1) cell growth was significantly different from that of the control; $n = 3$ or more, $P < 0.05$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent activity at the indicated concentration, and standard errors. [b]The hTERT immortalized hTERT-BJ1 was purchased from BD Biosciences Clontech.

Note: The results in this column are shown as means ± SE of experiments repeated five times. The different symbols qualify as in any concentration of treatment: Relative Cell Viability > 80%, Relative SEAP activity > 100% and P value below 0.05 analyzed with Two-tail T-test.

The ratio of relative cell viability under relative SEAP activity is over 1.2. All of SEAP data are shown as the result that drug-self interference has been subtracted

Table 7. Effects of Symmetrical 1,5-Diaminoanthraquinones (IVa-p) on Repressing hTERT Expression

No.	R	Conc (μM)[a]	P_{hTERT}-SEAP (hTERT-H1299)[b] Relative MTT viability (%)	Relative SEAP activity (%)	SEAP/vibility
IVa	CH_2CH_3	3.3	106±7.4	108±6.3	1.01
		33	104±3.7	101±6.8	0.97
		339	103±6.4	95±11.0	0.91
IVb	CH_2CH_2OH	3.0	105±6.3	91±3.9	0.86
		30	88±9.1	88±4.5	1.00
		308	53±2.8	5.7±1.1	1.08
IVc	$CH(CH_3)_2$	3.1	114±7.6	94±4.1	0.82
		31	111±4.7	93±2.0	0.84
		310	50±7.5	66±4.7	1.32
IVd	$CH_2CH_2N(CH_3)_2$	2.6	107±9.1	103±6.0	0.95
		26	81±8.3	54±5.9	0.67
		262	29±2.6	40±5.9	1.39
IVe	$CH_2CH_2NH(CH_2)_2OH$	2.4	97±8.7	87±3.8	0.89
		24	37±3.9	43±5.5	1.15
		242	11±4.1	40±6.7	3.77
IVf	$CH_2CH_2CH_3$	3.1	99±7.6	101±15.3	1.02
		31	98±5.8	100±5.6	1.03
		310	46±9.5	89±8.3	1.93
IVg	$CH_2CH(CH_3)_2$	2.8	108±4.8	94±7.0	0.87
		28	106±3.7	91±2.5	0.85
		285	80±4.8	75±4.1	0.94
IVh	$CH_2CH_2CH_2OH$	2.8	107±5.0	88±4.9	0.82
		28	49±3.5	69±5.4	1.41
		282	40±10.4	33±2.2	0.81
IVi	$CH_2CH_2CH_2NH_2$	2.8	85±11.5	102±4.9	1.20
		28	32±9.3	44±7.5	1.39
		283	16±2.1	38±6.0	2.34

IVj $CH_2CH_2CH_2CH_3$	2.8	102±7.0	106±7.1	1.04
	28	104±9.2	105±5.5	1.01
	285	81±13.9	98±5.2	1.21
IVk $CH_2CH_2CH_2CH_2NH_2$	2.6	114±8.1	89±4.9	0.78
	26	110±7.1	71±9.8	0.65
	265	16±3.4	27±2.0	1.65
IVl $CH_2CH_2CH_2CH_2CH_2CH_3$	2.4	99±5.3	101±6.1	1.02
	24	95±6.2	106±9.1	1.11
	245	85±8.8	104±9.4	1.22
IVm cyclopentane	2.6	114±7.5	98±4.5	0.86
	26	110±5.7	95±2.8	0.86
	267	86±8.2	90±4.8	1.05
IVn 2,3-$(CH_3)_2$-cyclohexane	2.1	88±7.9	103±9.2	1.17
	21	84±10.2	105±5.1	1.25
	218	58±8.0	96±4.5	1.64
IVo $CH_2C_6H_5$	2.3	98±8.4	99±5.0	1.01
	23	100±7.3	103±8.9	1.04
	238	40±8.4	97±3.8	2.45
IVp $CH_2CH_2C_6H_5$	2.2	94±5.2	105±3.0	1.12
	22	97±3.2	103±9.5	1.06
	223	77±4.2	96±2.9	1.25
Mitoxnatrone	1.9	100±5.6	81±3.8	0.82
	19	57±4.3	66±4.0	1.16
	193	39±3.2	47±3.9	1.21

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Repression of P_{hTERT}-SEAP (hTERT-H1299) cell growth was significantly different from that of the control; $n = 3$ or more, $P < 0.05$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent activity at the indicated concentration, and standard errors. [b]The hTERT cancer cell hTERT-H1299 was purchased from BD Biosciences Clontech.

Table 8. In vitro Cytotoxicity of 1,8-Diaminoanthraquinones (Va-p) Against the Growth of Suspended Murine and Human Tumor Cell Lines

Compound	R	IC_{50} (μM)[a]		
		C6 cells[c]	Hep G2[b]	2.2.15[d]
Va	CH_2CH_3	>20	>20	>20
Vb	$CH_2CH_2CH_3$	0.61±0.01	0.19±0.01	1.06±0.03
Vc	$CH_2CH_2CH_2CH_3$	>20	>20	>20
Vd	$CH_2CH(CH_3)_2$	1.32±0.01	>20	>20
Ve	$(CH_2)_5CH_3$	>20	>20	>20
Vf	$CH(CH_3)_2$	1.24±0.01	>20	>20
Vg	CH_2CH_2OH	0.02±0.01	>20	>20
Vh	$CH_2CH_2CH_2OH$	1.00±0.01	>20	>20
Vi	$CH_2CH_2CH_2CH_2OH$	0.41±0.02	1.65±0.13	>20
Vj	$CH_2CH_2N(CH_3)_2$	0.15±0.04	0.16±0.04	8.55±0.09
Vk	$CH_2CH_2CH_2NH_2$	>20	11.43±0.17	>20
Vl	$CH_2CH_2CH_2CH_2NH_2$	>20	11.47±0.34	>20
Vm	$CH_2CH_2CH_2CH_2CH_2NH_2$	0.11±0.01	0.09±0.01	1.29±0.06
Vn	Cyclopentane	>20	>20	>20
Vo	$CH_2C_6H_5$	1.66±0.09	>20	>20
Vp	$CH_2CH_2C_6H_5$	>20	>20	>20
	Mitoxantrone	0.07±0.01	2.0±0.50	0.40±0.02
	Adriamycin	1.00±0.16	0.90±0.01	1.60±0.04

[a]IC_{50}, drug concentration inhibiting 50% of cellular growth following 48 h of drug exposure. Values are in μM and represent an average of three experiments. The variance for the IC_{50} values was less than ±20%. Inhibition of cell growth was significantly different with respect to that of the control; $n = 3$ or more, $P < 0.01$. Inhibition was compared with that of the control (mitoxantrone-HCl, adriamycin, cisplatin), (μM), and standard errors. [b]Hep G2, human hepatoma G2 cells. [c]C6 cells, rat glioma C6 cells. [d]2.2.15 cells, hepatitis B virus transfected hepatoma cell lines, HepG 2.2.15 cells.

Table 9. In vitro Cytotoxicity of 1,4-Diamidoanthraquinones (VI_{1-37}) Against the Growth of Suspended Murine and Human Tumor Cell Lines

Compound	R	IC_{50} (μM)[a]		
		C6 cells[c]	Hep G2[b]	2.2.15[d]
VI_1	CH_2Cl	>20	>20	>20
VI_2	2-ClC_6H_4	>20	>20	>20
VI_3	CH_3	>20	>20	>20
VI_4	C_6H_5	>20	>20	>20
VI_5	3-ClC_6H_4	>20	>20	>20
VI_6	3-$CH_3C_6H_4$	>20	>20	>20
VI_7	CH_2CH_2Cl	>20	>20	>20
VI_8	2,4-$Cl_2C_6H_3$	>20	>20	>20
VI_9	$CHClCH_3$	>20	>20	>20
VI_{10}	2-FC_6H_4	>20	>20	>20
VI_{11}	2-$NO_2C_6H_4$	>20	>20	>20
VI_{12}	3-FC_6H_4	>20	>20	>20
VI_{13}	2,4,6-$Cl_3C_6H_2$	>20	2.77±0.93	3.63±2.33
VI_{14}	2,3,6-$F_3C_6H_2$	>20	>20	>20
VI_{15}	2,4,5-$Cl_3C_6H_2$	>20	>20	3.35±3.24
VI_{16}	4-ClC_6H_4	>20	>20	>20
VI_{17}	cyclohexane	>20	>20	>20
VI_{18}	2,4-$F_2C_6H_3$	>20	>20	>20
VI_{19}	$(CH_2)_2CH(CH_2)_4$	>20	>20	>20
VI_{20}	cyclopentane	>20	>20	>20
VI_{21}	cyclopropane	>20	>20	>20
VI_{22}	2-$SC(CH)_3$	>20	>20	>20
VI_{23}	2,3-Cl_2-5-FC_6H_2	>20	>20	>20
VI_{24}	2-$OC(CH)_3$	>20	>20	>20
VI_{25}	CH_2-2-S-$C(CH)_3$	>20	>20	15.47±12.00
VI_{26}	3-O-2,5-$(CH_3)_2CH$	>20	>20	>20
VI_{27}	$CH(CH_2)CHC_6H_5$	>20	>20	19.48±18.13
VI_{28}	$CH_2SC_6H_5$	>20	>20	>20

VI_{29}	$C_6H_3(CF_3)_2(o,m)$	2.82±0.47	>20	2.20±0.64
VI_{30}	$C_6H_4F(p)$	>20	>20	>20
VI_{31}	$C_6H_4CF_3(p)$	>20	>20	>20
VI_{32}	$CH_2C_6H_4F(p)$	>20	>20	>20
VI_{33}	$CH_2N(CH_2CH_3)_2$	4.46±2.76	0.65±0.62	12.97±11.93
VI_{34}	$(CH_2)_2N(CH_2CH_3)_2$	0.90±0.68	0.49±0.41	0.28±0.01
VI_{35}	$CHCH_3N(CH_2CH_3)_2$	18.09±14.11	2.02±0.26	8.57±7.18
VI_{36}	$CHCH_3NHCH_2CH(CH_2)_2$	2.76±1.74	6.46±1.40	3.46±1.15
VI_{37}	$CH_2CH_2NHCH_2CH(CH_2)_2$	0.40±0.09	0.32±0.29	1.71±1.67
	Mitoxantrone	0.07±0.01	2.0±0.50	0.40±0.02
	Adriamycin	1.00±0.16	0.90±0.01	1.60±0.04

[a]IC_{50}, drug concentration inhibiting 50% of cellular growth following 48 h of drug exposure. Values are in μM and represent an average of three experiments. The variance for the IC_{50} values was less than ±20%. Inhibition of cell growth was significantly different with respect to that of the control; $n = 3$ or more, $P < 0.01$. Inhibition was compared with that of the control (mitoxantrone-HCl, adriamycin, cisplatin), (μM), and standard errors. [b]Hep G2, human hepatoma G2 cells. [c]C6 cells, rat glioma C6 cells. [d]2.2.15 cells, hepatitis B virus transfected hepatoma cell lines, HepG 2.2.15 cells.

Table 10. Effects of Symmetrical 1,5-*bis*-thio-Substituted Anthraquinones (IIa-o) on Respressing and Activating hTERT Expression

No.	R	Conc. (μM)[a]	P_{hTERT}-SEAP (H1299)[b] Relative viability (%)	P_{hTERT}-SEAP (H1299)[b] Relative SEAP activity (%)	P_{hTERT}-SEAP (hTERT-BJ1)[c] Relative viability (%)	P_{hTERT}-SEAP (hTERT-BJ1)[c] Relative SEAP activity (%)
IIa	CH_2CH_3	3.0	111±2.8	134±14.4	112±9.2	109±22.4
		30	44±7.3	111±7.7	98±12.3	110±14.3
		300	25±2.3	99±14.3	34±18.1	104±20.6
IIb	CH_2CH_2OH	2.8	54±4.0	97±15.7	94±9.3	104±15.7
		28	29±7.0	76±12.4	49±2.9	98±10.9
		280	36±7.2	45±2.7	23±2.9	71±5.0
IIc	$CH_2CH_2CH_3$	2.8	96±5.9	73±5.4	103±6.3	132±21.0
		28	44±2.5	29±2.5	97±3.0	110±13.2
		280	25±2.4	17±13.9	39±4.9	122±14.3
IId	$CH_2CH(OH)CH_2OH$	2.4	102±6.2	105±21.6	98±10.7	144±16.9
		24	103±4.2	90±5.7	86±5.5	136±10.0
		240	83±18.2	81±6.1	79±8.2	142±9.1
IIe	$(CH_2)_6OH$	2.1	99±6.2	110±6.1	99±6.2	140±9.7
		21	94±3.9	100±5.5	70±2.2	128±14.4
		210	36±4.2	68±5.9	40±4.7	75±17.4
IIf	$2\text{-}NH_2C_6H_4$	2.2	94±3.5	108±12.2	103±7.9	136±17.5
		22	50±3.3	96±8.4	107±5.5	141±18.2
		220	14±2.5	59±6.6	25±3.3	115±29.7
IIg	$3\text{-}NH_2C_6H_4$	2.2	92±3.5	106±7.6	104±5.1	118±9.9
		22	68±1.9	109±11.7	9±3.4	41±9.5
		220	32±4.9	101±7.3	4±1.5	8±30.6
IIh	$4\text{-}NH_2C_6H_4$	2.2	103±4.3	100±5.7	86±11.9	97±17.9
		22	76±4.0	95±2.6	65±12.6	97±14.5
		220	42±2.3	84±5.3	56±13.8	26±12.6
IIi	$CH_2C_6H_5$	2.2	83±5.5	97±6.0	121±4.7	117±11.3
		22	44±0.9	100±7.2	98±4.2	112±9.3
		220	34±3.3	100±12.9	47±9.1	87±11.1

IIj	$CH_2C_6H_4(OCH_3)(p)$	2.2	89±6.1	92±3.3	119±9.4	142±27.7
		22	59±5.4	96±8.5	98±13.4	141±22.6
		220	42±.3	88±5.6	62±6.4	118±19.2
IIk	$CH_2CH_2C_6H_5$	2.2	93±6.2	108±0.5	91±3.9	119±12.2
		22	51±9.3	102±0.5	54±4.4	109±23.4
		220	27±2.9	97±4.8	35±4.1	110±30.6
IIL	$C_4H_3N_2$	2.3	107±5.1	105±6.6	104±8.9	137±12.3
		23	99±5.8	110±8.0	103±6.4	125±6.9
		230	44±6.3	49±10.0	73±8.3	61±8.7
IIm	C_5H_4N	2.3	79±12.2	104±12.6	112±6.4	98±12.3
		23	45±7.1	103±15.8	91±7.3	133±6.8
		230	29±1.5	89±9.3	55±11.3	121±13.8
IIn	$C_4H_2N_2(OH)(m)$	2.2	99±4.0	92±7.1	104±7.6	93±7.9
		22	95±4.9	97±2.9	106±6.3	116±15.4
		220	51±16.7	93±12.1	89±3.5	145±20.7
IIo	$C_6H_4CH_3$	2.2	84±5.9	117±12.5	111±5.4	132±19.3
		22	41±2.4	103±10.5	77±6.9	109±5.7
		220	25±2.4	90±11.6	22±8.5	87±29.6

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Activity of P_{hTERT}-SEAP (H1299) and (hTERT-BJ1) cell growth was significantly different with respect to that of the control; $n = 3$ or more, $P < 0.01$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are the mean percent activity at the indicated concentration, and include standard errors. [b]Non-small-cell lung cancer cells H1299. [c]The hTERT immortalized hTERT-BJ1 was purchased from BD Biosciences Clontech.

Table 11. Effects of Symmetrical 1,5-Bisacyloxyanthraquinones (IIIa-n) on Respressing and Activating hTERT Expression

No.	R	Conc. μM[a]	P_{hTERT}-SEAP (H1299)[b] Relative viability (%)	P_{hTERT}-SEAP (H1299)[b] Relative SEAP activity (%)	P_{hTERT}-SEAP (hTERT-BJ1)[c] Relative viability (%)	P_{hTERT}-SEAP (hTERT-BJ1)[c] Relative SEAP activity (%)
IIIa	$COCH_2CH_3$	2.8	116±8.0	103±5.8	99±11.9	131±7.0
		28	116±7.4	107±4.9	109±8.7	152±16.7
		280	87±6.6	97±3.1	93±10.8	161±12.2
IIIb	$COCH_2CH_2CH_3$	2.6	107±5.6	114±7.9	109±5.1	107±11.9
		26	106±3.2	118±8.4	106±5.6	119±8.3
		260	87±6.5	111±4.4	85±6.6	134±3.8
IIIc	$CO(CH_2)_4CH_3$	2.3	117±5.1	91±9.9	119±9.4	147±18.8
		23	114±4.7	95±17.4	98±13.4	149±16.1
		230	106±4.3	95±10.5	62±6.4	124±5.3
IIId	$COC(CH_3)_3$	2.4	106±8.9	105±4.9	94±3.4	147±11.1
		24	97±7.1	78±14.8	93±6.0	165±18.7
		240	70±5.2	80±10.1	100±9.0	141±14.4
IIIe	COC_6H_5	2.2	99±7.3	88±10.0	103±6.5	137±10.0
		22	60±11.9	94±8.0	87±9.8	122±9.6
		220	33±4.7	86±4.7	51±4.6	84±21.7
IIIf	$COC_6H_4Cl(o)$	1.9	74±5.3	93±4.4	107±5.5	120±10.5
		19	34±3.4	101±4.9	92±4.3	116±3.7
		190	30±1.4	97±5.3	40±4.0	97±10.8
IIIg	$COC_6H_4Cl(m)$	1.9	98±3.9	83±5.7	101±2.3	154±23.0
		19	88±7.2	92±8.1	80±6.7	152±15.8
		190	46±3.5	81±2.5	44±6.0	91±25.2
IIIh	$COC_6H_4Cl(p)$	1.9	91±10.0	106±4.5	111±6.5	136±5.7
		19	57±1.8	106±4.9	89±14.3	123±6.2
		190	31±1.0	97±4.9	48±9.0	107±6.0
IIIi	$COC_6H_4Cl_2(o,p)$	1.8	108±3.8	100±5.2	107±7.2	155±16.3
		18	103±5.9	102±5.4	102±4.1	150±13.9
		180	77±2.8	96±4.4	96±7.0	160±36.7

IIIj	$COC_6H_4CH_3(o)$	2.1	72±4.9	97±4.4	118±11.6	129±13.0
		21	36±9.7	91±7.4	82±8.5	120±24.0
		210	45±8.0	90±4.2	39±13.0	94±27.1
IIIk	$COC_6H_4CH_3(m)$	2.1	26±3.7	104±5.4	98±9.4	141±10.5
		21	28±5.0	116±12.8	54±7.5	124±15.6
		210	29±3.3	110±16.4	47±4.8	86±17.2
IIIL	$COC_6H_4CH_3(p)$	2.1	61±5.8	98±1.1	102±13.9	130±8.8
		21	33±2.8	95±4.3	98±6.3	126±13.3
		210	32±5.7	95±8.9	56±6.2	99±15.8
IIIm	$COCH_2C_6H_5$	2.1	91±4.2	98±0.3	106±9.0	129±4.5
		21	53±2.3	101±6.8	97±8.2	125±4.3
		210	30±1.6	142±14	64±10.2	100±17.3
IIIn	$COCH_2CH_2C_6H_5$	2.0	111±0.8	94±2.5	111±7.3	126±6.1
		20	101±4.3	98±4.7	106±6.6	124±13.4
		200	54±4.1	89±5.2	76±7.2	110±10.5

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Activity of P_{hTERT}-SEAP (H1299) and (hTERT-BJ1) cell growth was significantly different from that of the control; $n = 3$ or more, $P < 0.01$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are the mean percent activity at the indicated concentration, and include standard errors. [b]Non-small-cell lung cancer cells H1299. [c]The hTERT immortalized hTERT-BJ1 was purchased from BD Biosciences Clontech.

Table 12. Effects of Anthraquinones on the CMV Promoter Activity

Compd.	Concn[a] (μM)	P_{CMV}-SEAP (hTERT-BJ1)[b] Relative viability (%)	Relative SEAP activity (%)
IIf	2.2	108±9	103±8
	22	109±4	102±10
	220	48±6	122±8
IIj	2.0	116±13	103±15
	22	67±18	102±8
	220	52±7	100±8
IIn	2.2	107±10	112±15
	22	118±9	105±16
	220	78±18	120±14
IIIa	2.8	114±16	101±6
	28	110±12	112±6
	280	94±21	138±12
IIId	2.4	115±7	102±10
	24	104±8	114±18
	240	103±11	141±11
IIIi	1.8	105±8	99±15
	18	105±7	111±11
	180	108±15	121±17

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Activity of P_{CMV}-SEAP (hTERT-BJ1) cell growth was significantly different from that of the control; n = 3 or more, $P < 0.01$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are the mean percent activity at the indicated concentration and include standard errors. [b]CMV (cytomegalovirus); SEAP (secreted alkaline phosphatase).

Table 13. Effects of Symmetrical 1,4-Diamidoanthraquinones (VI_{1-37}) on Activating hTERT Expression

No.	R	Conc. (μM)[a]	P_{hTERT}-SEAP (hTERT-BJ1)[b] Relative MTT viability (%)	Relative SEAP activity (%)	SEAP/vibility
VI_1	CH_2Cl	2.5	101±2.7	123±16.8	1.23
		25	84±6.3	129±17.7	1.53
		255	44±4.7	121±10.9	2.76
VI_7	$(CH_2)_2Cl$	2.3	102±4.1	36±12.1	0.36
		23	82±8.2	40±10.8	0.48
		238	60±2.5	14±11.8	0.23
VI_9	$CH(Cl)CH_3$	2.3	94±10.4	91±10.8	0.97
		23	68±8.2	101±8.4	1.49
		238	48±2.3	81±8.5	1.68
VI_{33}	$CH_2N(CH_2CH_3)_2$	2.1	105±2.8	111±24.4	1.06
		21	86±3.5	120±25.6	1.40
		215	32±13.1	83±19.0	2.61
VI_{34}	$(CH_2)_2N(CH_2CH_3)_2$	2.0	83±9.2	2±11.1	0.03
		20	15±3.9	(-2)±11.2	-0.13
		203	6±3.9	(-2)±6.5	-0.37
VI_{35}	$CH(CH_3)N(CH_2CH_2)_2$	2.0	97±3.9	40±14.5	0.41
		20	52±7.2	49±9.3	0.94
		203	36±5.8	22±6.6	0.61
VI_{36}	$CH(CH_2)NCH_2CH(CH_2)_2$	2.0	103±6.4	91±19.4	0.88
		20	92±11.4	95±14.2	1.03
		204	104±17.4	65±15.7	0.63
VI_{37}	$(CH_2)_2NCH_2CH(CH_2)_2$	2.0	95±2.5	97±13.8	1.02
		20	84±1.5	124±22.8	1.48
		204	35±3.7	105±17.7	3.01
VI_3	CH_3	3.1	117±3.0	77±12.4	0.66
		31	95±11.9	83±10.0	0.87
		310	49±8.9	59±15.2	1.20

VI_{21} cyclopropane	2.6	103±6.8	64±9.5	0.62
	26	82±5.9	54±8.8	0.66
	267	58±4.1	43±8.3	0.74
VI_{20} cyclopentane	2.3	106±2.3	85±7.7	0.81
	23	103±4.4	93±18.5	0.90
	233	93±5.7	63±36.5	0.67
VI_{17} cyclohexane	2.1	102±3.0	65±16.0	0.64
	21	97±2.4	42±24.3	0.44
	218	83±4.2	56±16.3	0.68
VI_{19} $(CH_2)_2CH(CH_2)_4$	2.0	107±3.6	90±9.2	0.84
	20	101±4.7	87±5.5	0.87
	205	100±5.8	87±8.0	0.87
VI_{22} 2-$SC(CH)_3$	2.1	118±10.6	94±20.2	0.80
	21	99±8.2	92±17.4	0.93
	218	84±6.9	90±22.7	1.07
VI_{24} 2-$OC(CH)_3$	2.3	91±9.5	39±7.8	0.43
	23	69±10.7	45±11.0	0.65
	234	72±11.3	37±15.0	0.51
VI_{25} CH_2-2-$SC(CH)_3$	2.0	116±7.5	53±17.4	0.45
	20	105±4.4	40±12.7	0.38
	205	76±6.5	14±24.1	0.19
VI_4 C_6H_5	2.2	95±4.9	(-4)±25.7	-0.04
	22	69±3.2	(-10)±26.8	-0.14
	224	38±2.6	(-41)±26.8	-1.10
VI_6 3-$CH_3C_6H_4$	2.1	110±2.6	97±17.1	0.88
	21	109±4.6	78±7.1	0.71
	210	101±6.0	70±5.8	0.69
VI_{10} 2-FC_6H_4	2.0	106±6.5	95±8.9	0.90
	20	105±8.5	96±9.8	0.96
	207	86±7.3	79±7.4	0.92
VI_{12} 3-FC_6H_4	2.0	102±1.5	107±11.9	1.05
	20	97±2.9	108±15.5	1.11

	207	85±2.6	95±13.9	1.12
VI_{30} 4-FC_6H_4	2.0	103±9.0	104±16.3	1.01
	20	107±3.1	101±27.6	0.95
	207	83±5.3	100±14.5	1.20
VI_2 2-ClC_6H_4	1.9	116±7.7	110±20.1	0.95
	19	109±2.2	96±33.4	0.88
	194	95±2.0	95±36.6	1.00
VI_5 3-ClC_6H_4	1.9	99±9.8	98±10.1	0.99
	19	90±1.9	105±8.8	1.17
	194	60±2.0	89±10.1	1.48
VI_{16} 4-ClC_6H_4	1.9	111±0.8	116±28.6	1.05
	19	103±5.9	112±21.9	1.09
	194	99±5.2	152±39.7	1.54
VI_{11} 2-$NO_2C_6H_4$	1.8	110±4.1	102±33.4	0.92
	18	107±6.3	122±19.5	1.14
	186	99±3.2	114±28.1	1.15
VI_{31} 2-$CF_3C_6H_4$	1.7	98±4.4	100±15.1	1.02
	17	100±3.4	90±16.3	0.90
	171	89±3.6	103±17.6	1.16
VI_{29} 2,3-$(CF_3)_2C_6H_3$	1.3	107±6.4	16±31.8	0.15
	13	85±4.8	24±21.5	0.28
	139	56±4.6	26±36.9	0.47
VI_{18} 2,4-$F_2C_6H_3$	1.9	104±5.6	48±21.7	0.46
	19	101±4.4	51±18.5	0.50
	192	103±6.1	48±23.1	0.46
VI_8 2,4-$Cl_2C_6H_3$	1.7	102±3.4	33±11.2	0.32
	17	98±7.2	25±17.2	0.26
	171	76±4.8	39±12.8	0.52
VI_{13} 2,4,6-$Cl_3C_6H_2$	1.5	98±8.5	31±23.0	0.32
	15	63±7.0	12±12.5	0.19
	153	40±22.2	4±15	0.09
VI_{14} 2,3,6-$F_3C_6H_2$	1.8	102±3.3	35±14.1	0.35

	18	90±6.0	22±24.4	0.25
	180	70±6.8	31±7.9	0.44
VI_{15} 2,4,5-$F_3C_6H_2$	1.6	104±4.5	117±14.2	1.12
	16	89±5.0	114±20.4	1.29
	161	80±3.8	115±30.8	1.44
VI_{23} 2,3-Cl_2-5-FC_6H_2	1.6	111±6.8	113±16.0	1.02
	16	110±7.1	131±19.1	1.20
	161	101±6.6	106±17.3	1.05
VI_{27} $CH(CH_2)CHC_6H_5$	1.8	92±16.9	92±16.9	0.89
	18	97±18.2	97±18.2	0.99
	189	104±10.7	102±16.6	0.98
VI_{28} $CH_2SC_6H_5$	1.8	115±4.8	14±14.7	0.12
	18	105±6.7	23±9.5	0.21
	185	60±2.3	7±9.6	0.12
VI_{32} CH_2-4-FC_6H_4	1.9	107±7.2	90±18.4	0.84
	19	100±6.3	102±20.0	1.02
	195	96±4.1	97±11.6	1.01
VI_{26} 2,5-dimethylfuran	2.0	101±6.2	84±13.3	0.83
	20	101±5.8	79±14.7	0.78
	207	93±7.1	81±16.1	0.88

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Activity of P_{hTERT}-SEAP (hTERT-BJ1) cell growth was significantly different from that of the control; $n = 3$ or more, $P < 0.05$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent activity at the indicated concentration, and standard errors. [b]The hTERT immortalized hTERT-BJ1 was purchased from BD Biosciences Clontech.

Note: The results in this column are shown as means ± SE of experiments repeated five times. The different symbols qualify as in any concentration of treatment: Relative Cell Viability > 80%, Relative SEAP activity > 100% and P value below 0.05 analyzed with Two-tail T-test. The ratio of relative cell viability under relative SEAP activity is over 1.2. All of SEAP data are shown as the result that drug-self interference has been subtracted.

Table 14. Effects of Symmetrical 1,4-diamidoanthraquinones (VI_{1-37}) on Repressing hTERT Expression

No.	R	Conc (μM)[a]	P_{hTERT}-SEAP (hTERT-H1299)[b] Relative MTT viability (%)	Relative SEAP activity (%)	SEAP/vibility
VI_1	CH_2Cl	2.5	104±5.5	102±5.3	0.98
		25	96±3.8	110±8.8	1.14
		255	21±1.5	97±7.1	4.66
VI_7	$(CH_2)_2Cl$	2.3	99±6.0	87±2.3	0.88
		23	68±2.4	87±3.1	1.28
		238	30±3.8	68±5.3	2.30
VI_9	$CH(Cl)CH_3$	2.3	111±5.5	106±5.5	0.96
		23	77±3.4	109±1.0	1.40
		238	11±1.4	85±5.3	7.82
VI_{33}	$CH_2N(CH_2CH_3)_2$	2.1	105±4.9	98±3.3	0.94
		21	87±3.9	86±7.4	0.99
		215	44±2.7	48±2.3	1.11
VI_{34}	$(CH_2)_2N(CH_2CH_3)_2$	2.0	92±6.1	73±2.7	0.79
		20	11±2.5	53±2.7	4.63
		203	1±2.4	39±0.8	44.24
VI_{35}	$CH(CH_3)N(CH_2CH_2)_2$	2.0	96±7.9	96±14.3	1.00
		20	77±7.2	104±6.0	1.35
		203	75±4.6	73±11.7	0.98
VI_{36}	$CH(CH_2)NCH_2CH(CH_2)_2$	2.0	106±4.1	123±12.4	1.16
		20	64±5.1	112±11.5	1.76
		204	30±4.7	80±14.5	2.71
VI_{37}	$(CH_2)_2NCH_2CH(CH_2)_2$	2.0	108±7.8	95±4.2	0.88
		20	83±1.6	91±8.9	1.09
		204	67±9.8	52±4.4	0.77
VI_3	CH_3	3.1	109±3.5	85±2.3	0.78
		31	108±3.6	90±3.3	0.83
		310	37±1.3	80±3.1	2.16
VI_{21}	cyclopropane	2.6	95±4.2	108±4.9	1.14
		26	88±4.2	106±7.3	1.21
		267	41±4.6	92±5.9	2.23
VI_{20}	cyclopentane	2.3	107±6.1	119±8.5	1.11
		23	103±6.1	118±9.2	1.15
		233	92±8.6	113±8.9	1.23
VI_{17}	cyclohexane	2.1	104±6.4	104±1.8	1.00
		21	96±5.8	100±6.2	1.05
		218	67±1.5	93±2.5	1.38
VI_{19}	$(CH_2)_2CH(CH_2)_4$	2.0	105±2.1	111±9.4	1.06
		20	106±4.7	116±8.0	1.09
		205	95±1.3	109±9.2	1.15

VI_{22}	2-$SC(CH)_3$	2.1	108±3.7	100±3.1	0.93
		21	107±8.5	105±5.9	0.98
		218	84±4.3	97±4.9	1.16
VI_{24}	2-$OC(CH)_3$	2.3	101±6.0	99±7.8	0.99
		23	75±3.9	97±4.6	1.30
		234	32±5.1	90±2.9	2.83
VI_{25}	CH_2-2-$SC(CH)_3$	2.0	104±8.0	111±3.7	1.06
		20	83±6.6	115±4.3	1.39
		205	41±4.0	102±5.5	2.47
VI_4	C_6H_5	2.2	109±6.0	81±3.3	0.74
		22	88±6.2	84±2.6	0.96
		224	27±1.8	80±2.7	2.99
VI_6	3-$CH_3C_6H_4$	2.1	101±5.6	107±4.6	1.06
		21	97±6.2	104±4.0	1.08
		210	83±7.8	99±9.1	1.20
VI_{10}	2-FC_6H_4	2.0	116±2.4	105±7.8	0.91
		20	104±6.1	107±11.9	1.03
		207	77±2.6	103±14.4	1.34
VI_{12}	3-FC_6H_4	2.0	105±6.8	102±2.9	0.98
		20	96±7.4	110±6.5	1.14
		207	66±5.5	106±9.4	1.59
VI_{30}	4-FC_6H_4	2.0	110±5.9	111±3.6	1.01
		20	103±6.6	107±4.8	1.04
		207	89±6.7	107±9.0	1.20
VI_2	2-ClC_6H_4	1.9	114±5.4	108±10.5	0.94
		19	72±3.6	105±7.7	1.47
		194	60±7.9	100±8.9	1.68
VI_5	3-ClC_6H_4	1.9	95±11.3	110±4.9	1.17
		19	102±8.5	112±6.1	1.10
		194	59±4.3	91±3.0	1.55
VI_{16}	4-ClC_6H_4	1.9	89±5.5	109±6.8	1.23
		19	89±9.5	118±5.6	1.33
		194	79±5.6	116±12.3	1.46
VI_{11}	2-$NO_2C_6H_4$	1.8	104±6.3	105±4.3	1.00
		18	101±4.1	107±7.9	1.06
		186	86±5.3	94±8.0	1.10
VI_{31}	2-$CF_3C_6H_4$	1.7	98±7.8	110±5.5	1.12
		17	100±8.9	114±5.6	1.14
		171	77±6.7	96±2.1	1.24
VI_{29}	2,3-$(CF_3)_2C_6H_3$	1.3	99±8.6	106±6.7	1.07
		13	79±10.3	105±7.9	1.32
		139	37±8.8	94±10.2	2.56
VI_{18}	2,4-$F_2C_6H_3$	1.9	87±3.7	93±5.6	1.06
		19	85±7.1	99±5.4	1.17
		192	69±8.4	99±1.8	1.44
VI_8	2,4-$Cl_2C_6H_3$	1.7	106±3.9	85±7.9	0.80
		17	95±1.3	84±7.1	0.89
		171	83±1.2	87±2.6	1.06

VI_{13}	2,4,6-$Cl_3C_6H_2$	1.5	113±4.8	98±4.5	0.87
		15	107±5.4	66±2.4	0.61
		153	20±3.3	41±3.9	0.03
VI_{14}	2,3,6-$F_3C_6H_2$	1.8	111±2.9	91±5.2	0.82
		18	89±3.7	97±4.1	1.09
		180	55±3.3	91±3.3	1.64
VI_{15}	2,4,5-$F_3C_6H_2$	1.6	90±6.6	109±10.8	1.20
		16	81±1.9	118±10.3	1.45
		161	60±5.0	104±8.2	1.73
VI_{23}	2,3-Cl_2-5-FC_6H_2	1.6	98±7.0	102±4.1	1.04
		16	103±8.7	102±5.1	0.99
		161	87±5.1	83±4.0	0.95
VI_{27}	$CH(CH_2)CHC_6H_5$	1.8	101±2.4	95±7.7	0.94
		18	100±4.7	93±3.2	0.93
		189	94±3.5.	87±3.6	0.92
VI_{28}	$CH_2SC_6H_5$	1.8	104±5.6	93±3.2	0.89
		18	96±4.3	92±3.5	0.96
		185	59±3.8	80±4.0	1.35
VI_{32}	CH_2-4-FC_6H_4	1.9	108±8.8	109±10.8	1.00
		19	107±7.5	109±5.8	1.03
		195	78±8.0	109±6.6	1.39
VI_{26}	2,5-dimethylfuran	2.0	87±4.9	104±10.8	1.20
		20	71±2.3	103±10.0	1.46
		207	47±2.6	98±10.5	2.10
	Mitoxnatrone	1.9	100±5.6	81±3.8	0.82
		19	57±4.3	66±4.0	1.16
		193	39±3.2	47±3.9	1.21

[a]Values are in μM and represent an average of three experiments. The variance for the relative viability (%) and relative SEAP activity (%) values was less than ± 20%. Repression of P_{hTERT}-SEAP (hTERT-H1299) cell growth was significantly different from that of the control; $n = 3$ or more, $P < 0.05$. Relative percentage of inhibition was not compared with that of the control, $P < 0.01$, mean ± S.E., $n = 4$. Values are mean percent activity at the indicated concentration, and standard errors. [b]The hTERT cancer cell hTERT-H1299 was purchased from BD Biosciences Clontech.